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Review Article

Effects of Ginger (*Zingiber officinale*) as a Dietary Supplement on the Physiology and Health of Poultry

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ABSTRACT

The increasing incorporation of antibiotics into poultry feed for growth development and disease prevention has resulted in serious health implications and the emergence of antimicrobial-resistant bacterial strains. The present study aimed to investigate the effects of ginger (*Zingiber officinale*) powder, as a dietary supplement, on immune response, gut integrity, total antioxidant capacity, and hematological and biochemical parameters in different poultry breeds. The present review examined 76 studies on the effects of dietary ginger on the health and physiology of poultry, including broiler and layer chickens, quail, and turkeys. Only peer-reviewed, indexed, full-text articles published in English were considered and investigated. Natural alternatives, such as ginger powder and its derivatives, in poultry production systems have been shown to mitigate antibiotic-related challenges and have been widely incorporated into poultry feed mixtures. Ginger supplementation in the feed of laying hens, broiler chickens, broiler chicks, and quail has enhanced intestinal integrity and increased the immune response against several viral diseases affecting poultry, such as Newcastle disease, infectious bursal disease, and avian influenza. Ginger has reduced glucose, triglycerides, and total cholesterol levels and increased high-density lipoprotein levels, thereby improving hematological parameters such as red blood cell count, hemoglobin, and packed cell volume, as well as kidney and liver functions. Ginger reduced oxidative stress and improved antioxidant status. Dietary ginger supplementation in poultry diets could serve as a natural feed additive to enhance growth, immunity, and overall health across poultry species, although optimal dosage may differ by species, age, and health status.

1. Introduction

Scientific authorities have recently warned against using antibiotics in poultry feed to accelerate growth and combat pathogens, due to associated health and safety risks. These concerns stem primarily from serious health implications, including the development of antibiotic-resistant strains of pathogens[1]. Therefore, many studies have been conducted to explore natural alternatives, notably medicinal plants such as ginger, turmeric, and garlic, which contain therapeutic compounds that do not compromise the health of poultry or humans[2]. *Zingiber officinale*, commonly known as ginger, belongs to the family Zingiberaceae and is a perennial herbaceous plant that typically reaches a height of approximately one meter. Ginger features green, spear-shaped leaves and produces greenish-yellow flowers[3]. The part of ginger most commonly used is the thick rhizome, which is used globally as a spice and in traditional Chinese medicine[4]. Ginger contains functional aromatic oils and derivatives, including zingiberene, geraniol, citronellyl acetate, terpineol, linalool, borneol, neral, and flavonoids, as well as phenolic compounds[5,6]. Ginger is widely recognized for its medicinal, anti-inflammatory, and anti-allergenic properties[3-5]. In addition to its ability to lower blood glucose levels in broiler chickens[6], ginger is also noted for enhancing growth, physiological functions, immune responses, and resilience to stress[7,8]. Given these promising properties, ginger has become a particularly appealing option for substituting antibiotic

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growth promoters in poultry farming[7,8]. However, some individual studies have documented positive effects in different poultry species[8,9], a comprehensive synthesis of its impacts, particularly on immune response, gut integrity, antioxidant capacity, and hematological and biochemical parameters, has been poorly investigated. The present study aimed to investigate the effects of ginger powder, as a dietary supplement, on immune response, gut integrity, total antioxidant capacity (TAC), and hematological and biochemical parameters in different poultry species, including broiler chickens, laying hens, quail, and turkeys, across different ages.

2. Search criteria

The present study was exclusively based on studies published in indexed journals. Literature searches were conducted utilizing Scopus, Google Scholar, Web of Science, and PubMed. The search was performed using keywords such as *Zingiber officinale*, ginger, poultry, immunity, gut integrity, antioxidants, and hematology. The current investigations focused on studies examining the effects of ginger supplementation on poultry physiology, immunity, gut health, antioxidant status, and hematological parameters in poultry, including broiler chickens, laying hens, quail, and turkeys, at different ages, irrespective of geographic origin. The selected studies were screened and assessed for scientific quality and relevance prior to inclusion in the present study. Only peer-reviewed, indexed full-text articles were included to ensure data quality. Studies lacking complete sections or published in non-indexed journals, as well as non-English articles and irrelevant studies, were excluded. A total of 169 scientific articles were retrieved from electronic databases; after excluding duplicate studies (47), 122 remained. Another 35 studies were excluded after verifying their titles and summaries to ensure they were not relevant to the topic. The remaining studies (87 studies) were read and examined, and 11 studies were excluded for not meeting the required criteria for the present study. Therefore, 76 studies were included in the present study. A total of 37 original studies were selected for data extraction and summary tables; the remaining 39 articles were used to provide theoretical background and support the discussion and interpretation of the findings.

3. Effects of ginger on the physiology and health of poultry

Ginger can be used as a dietary supplement for poultry in powder form, as an extract, or in combination with other nutritional supplements, either by incorporating it into the diet or by dissolving it in drinking water[3,4]. Supplementation with ginger in poultry feed has been reported to improve hematological parameters such as hemoglobin and hematocrit[10], enhance immune response[11], reduce cholesterol levels[12], increase TAC[13], and promote kidney and liver function[14]. Furthermore, ginger helps prevent diseases and microbial infections, such as salmonellosis caused by *Salmonella* spp., colibacillosis caused by *Escherichia coli* (*E. coli*), and coccidiosis caused by Coccidia[15]. Poultry products can be free of harmful substances and safe for human health by incorporating ginger into poultry feed mixtures. Table 1 shows the nutrient content of the ginger plant[16].

Table 1. Nutrient content of the ginger

Elements	Content
Moisture	11 ± 1.41 (%)
Dry matter	90 ± 1.41 (%)
Ash	0.66 ± 0.2 (%)
Fiber	13.5 (%)
Fat	4.2 ± 0.2 (%)
Carbohydrates	92 ± 2.12 (%)
Protein	14.69 (%)
Energy	459.56 (Kcal/100 g)
Lead	0.005 (µg/g)
Cadmium	0.002 (µg/g)
Potassium	10245 (µg/g)
Calcium	351 (µg/g)
Sodium	385 (µg/g)
Iron	122 (µg/g)
Zinc	45.9 (µg/g)
Manganese	6.24 (µg/g)
Selenium	0.189 (µg/g)
Nickel	0.12 (µg/g)
Copper	0.018 (µg/g)
Cobalt	0.015 (µg/g)

Source: Al-Hadad et al.[16]

3.1. Immunity

Poultry's immune status can be improved by using ginger in its different forms, such as dried ginger powder, ginger extract, and ginger essential oil, or by adding it to several medicinal plant supplements, which in turn increase antibody titers (immunoglobulin levels) against poultry diseases such as coccidiosis, *Salmonella* infections, and Newcastle disease[17,18]. Table 2 shows the different effects of ginger on the immune status of poultry.

Table 2. Effects of ginger on the immune status of different poultry breeds

Treatment	Poultry species	Effects/outcomes	Reference
Vitamin E, ginger, and L-carnitine at 250 mg/kg, 2 g/kg, and 500 mg/kg of feed	Broiler chickens	An increase in the average antibody titer against the infectious bursal disease	(19)
Red ginger powder at 2% of the feed	Broiler chickens	A decrease in tissue damage in the cecum and ileum, as well as a decrease in the number of *Salmonella* spp. in the intestine	(20)
Ginseng and ginger powders at 5 g/kg or as a combination of 2.5 g/kg of feed	Broiler chickens	An increase in the number of WBC, the number of RBC, hemoglobin, and the PCV, as well as an increase in the number of total antibodies (immunoglobulins) against the avian influenza virus	(11)
Ginger powder at 0.25, 0.5, and 0.75%	Quail	Increase in immune globulin, WBC, spleen percentage, and bursa size, as well as the number of Harderian glands	(21)
Ginger powder at 125, 250 mg/kg of feed, and bee Propolis at 500, 1000 mg/kg of feed	Quail	Statistically significant increase in the proportion of NDV antibodies against ND, and a statistically significant increase in the number of WBC (lymphocyte count)	(15)
Ginger powder at a rate of 3, 6, 9 g/kg of feed	Broiler chickens	Increase in the level of NDV antibodies in the blood against ND	(22)
The mixture of anise and ginger extracts at 2 g + 4 g, 2.5 g + 5 g, 3 g + 6 g, was added to the drinking water	Broiler chickens	Increase in total antibody titer against ND, bronchitis, and bursa	(23)
Ginger extract at 1 g/kg of feed	Ostrich chicks	Increase in total antibody titers against ND and improve the effectiveness of the ND vaccine	(17)
Ginger and garlic aromatic oils mixture at 0.5, 1, 1.5, and 2 ml/L	Broiler chickens	Significant increase in IgG and IgM levels, boosting the immune response	(24)
Ginger powder at a rate of 6 g/L of water	Broiler chickens	An increase in the number of T-cells (+CD4) and an increase in gene expression for IFN-γ in the cecal epithelium. Furthermore, ginger helped treat intestinal coccidiosis.	(18)
Ginger extract at 5 g/kg of feed	Laying hens	Decrease in serum cytokines, including TNF-α, IL-6, IL-1β, and elevated IL-10, IgG, and IgA levels	(25)

IgA: Immunoglobulin A, IgG: Immunoglobulin G, IgM: Immunoglobulin M, IFN-γ: Interferon gamma, IL-6: Interleukin 6, IL-1β: Interleukin 1 beta, IL-10: Interleukin 10, ND: Newcastle disease, NDV antibodies: Anti-Newcastle disease virus antibodies, PCV: Packed cell volume, RBC: Red blood cells, TNF-α: Tumor necrosis factor alpha, WBC: White blood cells

The improvement in the immune status of different poultry types when using ginger and other plant supplements may be related to the many properties of ginger supplements, such as anti-inflammatory, antioxidant, and antimicrobial effects, as well as their ability to provide essential minerals that support immune cells[23]. Ginger has been observed to enhance antibody levels against diverse viral illnesses, including Newcastle disease, bronchitis, and Gumboro disease, likely attributable to its active constituents, shogaol and gingerol, which mitigate oxidative stress and bolster the immune system[26-28]. Moreover, ginger administration has been associated with an increase in the weight of immune organs such as the spleen, thymus gland, and bursa, owing to its anti-inflammatory[5,29] and antimicrobial properties[30]. Ginger powder supplementation at a rate of 0.4% in the diet of broiler chickens increased total protein, albumin, and globulin associated with the humoral immune response[31]. Ginger significantly increased the number of T-cells (CD4), expression of interferon gamma (IFN-γ), and immune cells in broiler chickens, compared with untreated infected chickens, due to its ability to treat infections and reduce contributing factors to infection, such as tumor necrosis factor (TNF) and interleukin six (IL-6)[18]. The use of red ginger powder at 2% of the feed as a dietary supplement for broiler chickens reduced *Salmonella* spp. count by stimulating mucus production, to prevent pathogenic bacteria from sticking to the inner surface of the gut villi; consequently, preserving the immune organs such as the cecum and ileum[20]. The use of ginger powder in the quail diet at a rate of 2 g/kg of feed increased white blood cell (WBC) counts and globulin levels, indicating immunity, antibody production, and immunoglobulin secretion, thereby boosting immunity[19]. Ginger powder in the turkey poults' diet at a concentration of 4 g/kg of feed increased the number of WBC, which could be due to the physiological activity of turkeys to raise their immunity after taking a large amount of the active substances contained in ginger[32]. Additionally, Valdez et al.[27] and Hassan et al.[33] found that ginger significantly increased WBC counts. Therefore, ginger can improve the immune system in poultry against many diseases.

3.2. Intestinal health

Table 3 shows the effects of ginger on the health of poultry's intestines.

Table 3. Effects of ginger on the intestinal health status in different poultry breeds

Treatment	Poultry species	Effects/outcomes	Reference
Ginger powder was used as a multi-strain probiotic at 0.15, 0.20, and 0.25% in the feed	Broiler chickens	An increase in *Lactobacillus* bacterial counts in the ileum, thereby improving intestinal health	(34)
Ginger powder at 3, 6, and 9 g/kg of feed	Broiler chickens	Increase in intestinal villus length and width, deeper crypts, and a decrease in total bacterial count	(21)
Basil leaves, garlic powder, and ginger powder were each added separately at a rate of 50 ml/L in drinking water	Broiler chickens	Ginger alone demonstrated no coccidial egg count, whereas all treatments collectively exhibited a significant reduction in coccidial lesions.	(35)
Protease enzyme derived from ginger at 0.01 and 0.02% of diet	Quail	significant increase in intestinal villus height and width, therefore, enhancing nutrient digestion	(36)
Ginger and garlic aromatic oils mixture at 0.5, 1, 1.5, and 2 ml/L	Broiler chickens	A significant decrease in yeasts, molds, bacteria, *Escherichia coli*, and *Salmonella* spp. was observed, while lactic acid bacteria were observed.	(24)
Ethanol extract of ginger at 200, 400, and 600 mg/kg of feed	Dawu Golden Phoenix laying hens	Improved the beneficial microflora in the cecum and increased the beneficial intestinal probiotics	(37)
Ginger extract at 5 g/kg of feed	Laying hens	Enhanced intestinal microbiota function and increased *Lactobacillus* count, thereby inhibiting some pathogens and reducing inflammation.	(25)

Ginger powder may enhance villus length and width, as well as increase crypt depth in the duodenum, using the enzyme protease extracted from ginger; consequently, enhancing villus length, supporting nutrient absorption, improving intestinal health, and improving digestion[38,39]. This improvement in intestinal morphology has been reported by Asghar et al.[22], who found that ginger increased villus height and crypt depth. Crypt cells play key roles in secreting electrolytes. Accordingly, water content increases in the intestine, thereby improving digestion and supporting overall poultry health[40]. Furthermore, dietary supplementation with ginger and turmeric powder has been shown to reduce colonization by pathogenic bacteria, including *Salmonella* spp. and *E. coli*, as well as by the protozoan parasite responsible for coccidiosis[41]. The administration of ginger yeast cultures at 10 g/kg of feed was observed to enhance the digestion of nutrients, including crude protein and crude fat, in laying hens[42]. This effect was attributed to the presence of bioactive compounds in ginger, namely shogaol and gingerol, which stimulate 5-HT3 receptors in intestinal cells[43]. Furthermore, ginger facilitates the activation of lipase, sucrase, and protease enzymes, thereby supporting gastrointestinal digestion[42,44]. In Addition, Zhang et al.[45] demonstrated that administering *Saccharomyces cerevisiae* cultures to laying hens increased digestive enzyme activity in chyme and reduced plasma toxin concentrations. The use of ginger and cinnamon oils in Japanese quail has improved gut health[46] due to their roles in enhancing feed digestion and their rich antioxidant content. Beneficial gut bacteria, such as *Lactobacillus* and *Bifidobacterium*, reduce histological damage and support epithelial cell health[47]. These findings are consistent with a previous report showing that dietary supplementation with ginger and cinnamon can protect the intestines against microbial and parasitic infections[48].

3.3. Antioxidant status

Antioxidant status is considered a significant indicator of the capacity to mitigate oxidative stress. The associated studies and findings regarding the effects of ginger on antioxidant status are summarized in Table 4.

Table 4. Effects of ginger on antioxidant status in different poultry breeds

Treatment	Poultry species	Effects/outcomes	Reference
Ginger powder at 5, 10, 15 g/kg of feed and thymol at 200, 400 mg/kg of feed	Broiler chickens	A statistically significant decrease in MDA content and GSH levels was observed in the muscles	(49)
Chinese herbal medicine and ginger mixture at 3.32, 10 g/kg of feed	Laying hens and broiler chickens	Significant increase in nitric oxide levels, GSH-Px, and TAC	(13)
Ginger root powder at 1000 mg/kg of ration	Male quail	A reduction in GSH and MDA levels	(50)
Ginger yeast cultures at 5, 10, 20, 40 g/kg of feed	Laying hens	Enhancement in SOD, GSH-Px, POD, and MDA levels	(42)
Ginger powder at 1 g/kg of feed	Aged broiler cocks	An increase in anterior sperm motility and an increase in TAC in semen	(51)
Ginger powder at 5, 10 g/kg of feed	Laying hens	Enhancement in antioxidant status, gizzard and liver health, and a decrease in MDA content	(52)
Ginger and garlic aromatic oils mixture at 0.5, 1, 1.5, and 2 ml/L	Broiler chickens	Enhancement in antioxidant status, an increase in SOD, CAT, TAC, GSH, GSH-Px levels, and a decrease in MDA level	(24)

CAT: Catalase, GSH: Glutathione, GSH-Px: Glutathione peroxidase, MDA: Malondialdehyde, POD: Peroxidase, SOD: Superoxide dismutase, TAC: Total antioxidant capacity

Poultry growth is hindered by oxidative stress caused by free radicals. As a result, chickens were susceptible to various issues such as dropsy and sudden death syndrome[53]. Medicinal plants containing antioxidants can be used as nutritional supplements in poultry feed mixtures to reduce oxidative stress[54]. Markers such as malondialdehyde (MDA), TAC, superoxide dismutase (SOD), glutathione (GSH), glutathione peroxidase (GPx), and catalase (CAT) indicate antioxidant status and oxidative stress[55]. Ginger supplementation in quail feed has lowered MDA levels[51], likely because ginger contains gingerol and shogaol compounds that protect cells from oxidative damage caused by free radicals[56]. Additionally, the reduction in serum MDA levels may result from ginger's ability to decrease lipid peroxide formation, thereby enhancing antioxidant activity. Ogbuewu et al.[57] observed that supplementing the diet of broiler breeder hens with ginger at a concentration of 2.5 g/kg of feed resulted in a reduction in MDA levels compared to the control group. Ginger and cinnamon oils in quail feed increased TAC, SOD, GSH, GPx, and CAT levels and decreased MDA levels due to their capacity to scavenge free radicals and increase antioxidant enzyme activity[46]. Therefore, ginger is considered a powerful antioxidant[58]. The use of ginger and Chinese herbs as dietary supplements in laying hens has led to increased GSH levels, which may be attributed to their ability to promote GSH capture of free radicals[14]. Glutathione, known as the main antioxidant in the body, protects DNA from oxidative damage and neutralizes free radicals. Therefore, ginger is considered necessary to reduce reactive oxygen species that impede cellular regulation[55].

3.4. Hematological and biochemical parameters

Hematological parameters are important indicators of physiological and health status, and the effects of ginger on these parameters are summarized in Table 5.

Table 5. Effects of ginger on the hematological and biochemical parameters in different poultry breeds

Treatment	Poultry species	Effects/otcomes	Reference
Ginger powder at 2, 4 g/kg of feed	Turkey	Significant increase in RBC, serum albumin, and improved liver enzyme activity, reflecting the positive effect of ginger on blood and liver functions	(32)
Ginger powder at 2, 4, 6 g/kg of feed	Broiler chickens	Significant increase in WBC count, the total protein levels, along with reductions in cholesterol, HDL, VLDL, and triglyceride levels in the blood serum	(41)
Ginger extract at 100 g/ton of feed	Laying hens	Decrease in cholesterol, MDA content in yolk, along with reduced ALT and AST enzyme activity in the blood serum	(59)
Ginger at 0.5%, black pepper at 0.5%, 0.25% ginger + 0.25% black pepper	Broiler chickens	Significant differences in increased PCV and RBC, along with a decrease in ALT, AST, total cholesterol, LDL, and VLDL	(60)
Enzyme phytoprotease derived from ginger at 50 and 100 mg/kg of feed	Broiler chickens	Reduction in triglycerides and LDL levels	(39)
Ginger powder at 0.2, 0.4, 0.6% of feed	Broiler chickens	Significant decrease in triglycerides, total cholesterol, and VLDL and LDL, along with an increase in HDL levels	(10)
Ginger powder at 5, 10, 15 g/kg of feed	Broiler chickens	Increased WBC count and heterophils, improved digestion of dry matter, protein, and crude fiber, along with reduced cholesterol, triglycerides, and VLDL in blood	(33)
Ginger powder at 1 g/kg of feed	Aged broiler roosters	Increased anterior sperm motility and sperm production index in testes, along with elevated TAC in semen, and decreased total protein in blood	(51)
Ginger powder at 15 g/kg of feed	Male quail	Increase in ejaculation volume, sperm concentration, motility, vitality, and egg penetration ability, along with a reduction in total cholesterol level	(61)
Ginger powder at 1000 mg/kg of feed	Male quail	Reduction in blood glucose, cholesterol, and triglyceride levels	(62)
Stevia and ginger extracts at 0.5, 1, and 1.5% of feed	Quail	Reduction in AST, glucose, and cholesterol levels in blood serum	(12)
Ginger oil at 0, 0.5, 1 ml/kg of feed	Quail	Significant differences in urea, cholesterol, and AST levels	(46)
Ginger powder at 0.5% to 1% of feed	Broiler chickens	Decrease in triglycerides, cholesterol, and ALT and AST levels	(14)
Ginger and garlic powder at 0.25%, 0.5%, and 1.25% for each, either alone or in combination	Broiler chickens	No significant differences in PCV, hemoglobin, WBC, and their differential components, with a notable increase in RBC count	(63)
Turmeric at 0.75% + ginger 0.75% of feed	Laying hens	Significant differences in RBC, hemoglobin level, and WBC	(64)

ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, MDA: Malondialdehyde, PCV: Packed cell volume, RBC: Red blood cell, TAC: Total antioxidant capacity, VLDL: Very low-density lipoprotein, WBC: White blood cell

Ginger powder in Japanese quail feed was associated with a decrease in blood glucose[62]. This decrease in blood glucose levels can be attributed to the phenolic compounds in ginger, which exhibit hypoglycemic properties[65]. Alternatively, a decrease in blood glucose may be due to the ability of ginger's bioactive constituents to increase insulin secretion, thereby promoting glucose uptake by cells and reducing blood glucose levels[66]. Umoru and Agbaye[67] demonstrated that ginger reduced blood glucose in broiler chickens. Ginger supplementation in the feed of laying hens has reduced blood triglyceride levels, which may be due to ginger's high fiber content, thereby reducing fat absorption in the intestines68, or to the presence of HMG-CoA reductase in ginger enzyme[69]. Ginger contains oleoresin, including shogaol and gingerol[70], which prevents the absorption of bile salts in the intestines and stimulates the liver to produce new bile salts from cholesterol; consequently, cholesterol levels decrease in blood serum[33]. Moreover, it was found that ginger contains compounds that reduce cholesterol absorption from the intestine in laying quail[71]. Ginger also lowers blood cholesterol levels by stimulating enzymes involved in glycogen synthesis[72]. The enzymes aspartate aminotransferase (AST) and alanine aminotransferase (ALT), which are produced in the liver, are routinely measured to evaluate hepatic health. When a liver injury occurs, ALT and AST levels are elevated in blood serum[73-75]. Ginger powder in the feed of laying hens and broiler chickens was associated with decreased AST and ALT levels in the blood[71]. This can be attributed to the presence of gingerols (6-gingerols) in ginger, which protect the liver from damage[76]. There are criteria for kidney health, namely creatinine and uric acid. The use of aromatic ginger and garlic oils in broiler chickens' feed resulted in decreased creatinine and uric acid levels, owing to the antioxidant and anti-inflammatory properties of these oils[24]. In contrast, Liu et al.[42] indicated that using ginger as a feed additive in poultry did not significantly affect AST and ALT levels.

4. Conclusion

The present study demonstrated that dietary supplementation with ginger in poultry significantly improved TAC and enhanced gut integrity. It is noted that ginger supported immune function and regulated key hematological and biochemical parameters, including AST, ALT, cholesterol, glucose, and triglycerides, in different poultry breeds. Adding ginger to poultry diets could improve performance, antioxidant capacity, and birds' overall health; however, more investigation is needed to determine optimal inclusion levels, supplementation duration, and species- and production-system-specific responses, especially under diverse environmental and physiological stress conditions.

Declarations

Authors' contributions

Mohammad Abdalrahem Alhussen conceived the review topic, conducted the literature search, selected relevant studies, analyzed and synthesized the findings, and wrote

and revised the manuscript. The author read and approved the final edition of the manuscript before publication in the present journal.

Availability of data and materials

All datasets are available upon request from the corresponding author. No data were generated in the present study, and all information and findings are derived from previously published studies for this review article.

Competing interests

The author declared no competing interests.

Ethical considerations

The author confirmed that ethical concerns, such as plagiarism, permission to publish, research misconduct, data fabrication or falsification, duplicate submissions, and redundant publication, have been thoroughly reviewed. No AI-assisted technologies were used in the generation of this manuscript.

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